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13. ABSTRACT (Maximum 200 words) The MIT Research Laboratory of Electronics Joint Services Program comprises seventeen work units (see below) that span a broad array of topics in high-speed optics, surface and phase transitions, submicron structures and quantum-effect devices, the electrical behavior of interconnect structures, and atomic and molecular physics. The work units include: InGaAlAs Quantum Heterostructures for High-Performance Devices; InAlAs/InGaAs Heterostructure Field-Effect Transistors for Telecommunications; Chemical Beam Epitaxy of II-VI/III-V Quantum Wells; Sub-100nm Structures: Technology and Electronics; Single-Electron Transistors; Quantum Transport in Low-Dimensional Disordered Systems; Statistical Mechanics of Quantum Dots; Femtosecond Quantum Optics; Ultrafast Optical and Electronic Processes; Excitations, Ground State Properties, and Phase Transitions of Surfaces; Synchrotron X-ray Studies of Surface Disorder; Statistical Mechanics of Surface Systems and Quantum-Correlated Systems; Step Structures and Epitaxy; Molecular Beam Etching of and Deposition on Silicon; Optical Frequency Metrology; Precision Instrumentation; Electromagnetic Waves in Multilayer Media.				
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“Basic and Applied Research in the Field of
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November 1, 1991 - October 31, 1994**

**Research Laboratory of Electronics
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139-4307**

**Submitted by
Professor Jonathan Allen, Principal Investigator
February 1995**

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**Overview of the
MIT Research Laboratory of Electronics
Joint Services Electronics Program
for the period
November 1, 1991 - October 31, 1994**

The MIT Research Laboratory of Electronics Joint Services Program comprises seventeen work units that span a broad array of topics in high-speed optics, surface and phase transitions, submicron structures and quantum-effect devices, the electrical behavior of interconnect structures, and atomic and molecular physics.

The RLE program has developed and utilized state-of-the-art epitaxial growth techniques for high-performance devices that use indium gallium aluminum arsenide quantum heterostructures, as well as indium aluminum arsenide/indium gallium arsenide heterostructure field-effect transistors for high-speed, high-power telecommunication applications. The RLE program is unique in that it provides II-VI and II-V integrated growth facilities for a variety of projects, most notably the metalorganic molecular beam epitaxy of zinc selenide for blue light-emitter applications.

The RLE program continues to provide a strong array of capabilities in the sub-100-nanometer structure area, which is essential for our research in quantum-effect devices. Our x-ray nanolithography capability continues to expand. This will lead to the ability to grow extremely small MOSFETs with channels less than one-tenth of a micron in length. The acquisition of an electron beam lithographic capability has complemented our x-ray facilities. This has enhanced both our direct-write and mask masking capabilities.

Experiments with the single-electron transistor, which were previously reported, are aimed at developing new techniques to decrease the scale of these devices. This will enable these devices to operate at higher temperatures. Theoretical efforts have also been directed at single-electron transistors with a view towards understanding basic theory and revealing possibilities for new directions. The theoretical research is also focused on the statistical mechanics properties of quantum dots and how they can be utilized for new device applications.

Femtosecond optical capability is aimed at the provision of all-optical networks and all-optical switching by using compact, solid-state lasers that exhibit additive pulse modelocking. Soliton transmissions have been studied and implemented in these networks, thus permitting extremely long distances between repeaters in practical systems. The femtosecond optical capability is also utilized to probe electronic materials and to optimize transport properties in extremely fast electronic devices.

Surfaces are central to modern electronic and optical devices, and the RLE program continues its strong theoretical effort to characterize surface phase transitions, impurities, and stress. Realistic surface profiles are computed, and defect complexes on surfaces have been realistically characterized. Experimentally, synchrotron x-ray diffraction studies using high-power x-ray facilities have revealed new surface phenomena, including the ability to move plateaus on silicon surfaces through the introduction of surface currents. A detailed understanding of the atomic

mechanisms of surface reconstruction has been obtained. The understanding of surface roughness, which is essential for many applications, has led to a better understanding of new fabrication techniques. By using accelerated neutral halogen atoms, surface reactions (similar to those found in reactive ion etching) have been studied in detail. New techniques that avoid high pressure and associated surface defects have been devised for surface etching.

Many electronic and optical systems require extremely high-precision measurements and standards. The RLE JSEP program has pioneered the development of optical frequency standards. These developments can then be exploited in many electronic systems that involve the synchronization and coordination of worldwide systems. Highly accurate techniques to measure mass are now available for ultrahigh-resolution studies of electronic and optical materials. These techniques also provide a uniform and portable ultraprecision standard for mass.

RLE participates with other JSEP universities in electromagnetic studies. The focus at RLE is on propagation through multilayer media, such as that found in computer interconnect structures. Direct solutions in the time domain have provided a new understanding and the capability to decrease the delays imposed by these networks.

A continuing direction of the RLE program is the study and exploitation of individual atoms and molecules, as well their contribution to the behavior of practical electronic and optical devices. The direct control of individual charge carriers is now feasible, and there is an increased understanding of possibilities for new quantum-effect devices based on cavity quantum electrodynamics in solid-state Coulomb blocking effects. The RLE program continues its efforts to realize new, practical devices with outstanding performance to exploit these effects.

**Principal Investigators
Supported by the
Joint Services Electronic Program**

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**Degrees Awarded under Joint Services Support
November 1, 1991 - October 31, 1994
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InGaAlAs Quantum Heterostructures for High-Performance Devices

Broekaert, T.P.E., Ph.D., 1992

InAlAs/InGaAs Heterostructure Field-Effect Transistors for Telecommunications

Bahl, S.R., Ph.D., 1993

Chemical Beam Epitaxy of II-VI/III-V Quantum Wells

No degrees reported.

Sub-100nm Structures: Technology and Electronics

Modiano, A.M., Ph.D., 1992

Moolji, A.A., S.B., 1993

Olster, D.B., S.B., 1992

Single-Electron Transistors

No degrees reported.

Quantum Transport in Low-Dimensional Disordered Systems

No degrees reported.

Statistical Mechanics of Quantum Dots

No degrees reported.

Femtosecond Quantum Optics

Hall, K.L., Ph.D., 1993

Khatri, F.I., S.M., 1992

Ultrafast Optical and Electronic Processes

No degrees reported.

Excitations, Ground State Properties, and Phase Transitions of Surfaces

No degrees reported.

Synchrotron X-ray Studies of Surface Disorder

Nuttal, W.J., Ph.D., 1993

Statistical Mechanics of Surface Systems and Quantum-Correlated Systems

No degrees reported.

Step Structures and Epitaxy

Abernathy, D.L., Ph.D., 1993

Molecular Beam Etching of and Deposition on Silicon

Yang, J.J., Ph.D., 1993

Optical Frequency Metrology

No degrees reported.

Precision Instrumentation

No degrees reported.

Electromagnetic Waves in Multilayer Media

Tassoudji, M.A., Ph.D., 1994

Publications Acknowledging Joint Services Support

November 1, 1991 - October 31, 1994

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1.1.1 Published Journal Articles

- Abernathy, D.L., D. Gibbs, G. Grubel, K.G. Huang, S.G.J. Mochrie, A.R. Sandy, and D.M. Zehner. "Reconstruction of the (111) and (001) Surfaces of Au and Pt: Thermal Behavior." *Surf. Sci.* 283: 260 (1993).
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1.1.3 Books/Chapters In Books

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- Bahl, S.R. *Physics and Technology of InAlAs/n⁺-InGaAs Heterostructure Field-Effect Transistors*. Ph.D. diss., Dept. of Electr. Eng. and Comput. Sci., MIT, 1993.
- Broekaert, T.P.E. *Characterization of InGaAlAs Resonant Tunneling Transistors*. Ph.D. diss., Dept. of Electr. Eng. and Comput. Sci., MIT, 1992.
- Hall, K.L. *Femtosecond Nonlinearities in InGaAsP Diode Lasers*. Ph.D. diss., Dept. of Electr. Eng. and Comput. Sci., MIT, 1993.

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1.1.5 Technical Reports

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- Chu, W. *Inorganic X-ray Mask Technology for Quantum-Effect Devices*. RLE TR-577. MIT, 1993.
- Ghanbari, R.A. *Physics and Fabrication of Quasi-One-Dimensional Conductors*. RLE TR-578. MIT, 1993.

1.1.6 Meeting Papers Presented

- Advanced Heterostructure Transistors Conference*, Keauhou-Kona, Hawaii, November 29-December 4, 1992.
- del Alamo, J.A., S.R. Bahl, and D.R. Greenberg. "In-P-Based High Breakdown Voltage HFETs."
- Hu, Q., C. Eugster, and J.A. del Alamo. "Photon-assisted Quantum Transport in Quantum Point Contacts."
- American Chemical Society Meeting*, Denver, Colorado, March 23, 1993.
- Ceyer, S.T. "A New Mechanism for Dissociative Chemisorption on Si: Atom Abstraction."
- American Chemical Society Meeting*, Washington, DC, August 24-28, 1992.

- Pullman, D.P., Y.L. Li, J.J. Yang, and S.T. Ceyer. "Reaction Dynamics of F₂ on Si(100)."
American Physical Society Meeting, Annual, Washington, DC, April 14, 1993.
- Pritchard, D.E. "Single Ion Mass Spectroscopy."
American Physical Society Meeting, Indianapolis, Indiana, March 16-20, 1992.
- Aalberts, D.P., and A.N. Berker. "Hard-Spin Mean-Field Theory: Variational Free Energy and First-Order Phase Transitions."
- Berker, A.N., and R.R. Netz. "Smectic C Order, In-Plane Domains, and Nematic Reentrance in a Frustrated Microscopic Model of Liquid Crystals."
- Kumar, A. "Electron States and Potentials in Quantum Dot Structures."
- Netz, R.R. "Symmetry-Breaking Fields in Frustrated Ising Systems on Square and Cubic Lattices."
- Zhao, Y., D.C. Tsui, K. Hirakawa, M. Santos, M. Shayegan, R. Ghanbari, D.A. Antoniadis, and H.I. Smith. "Far Infrared Magneto-Absorption by the 2 DEG in GaAs/AlGaAs Heterostructures with Grid Gates."
- American Physical Society Meeting*, Pittsburgh, Pennsylvania, March 21-25, 1994.
- Hui, K., and A.N. Berker. "Analytic Expression for the Exact Boundary of the Superantiferromagnetic Phase of the Ising Model with Nearest- and Next-Nearest-Neighbor Interactions on the Square Lattice."
- Falicov, A., and A.N. Berker. "Finite-Temperature Phase Diagram of the tJ Model: Renormalization-Group Theory."
- American Physical Society Meeting*, Seattle, Washington, March 22-26, 1993.
- Berker, A.N., and K. Hui. "Phase Diagram of the Ising Model on the Square Lattice with Crossed Diagonal Bonds."
- Meade, R.D., and J.D. Joannopoulos. "Photonic BandGap Material for Laser Applications."
- Netz, R.R., and A.N. Berker. "Renormalization-Group Theory of an Internal Critical Endpoint Structure: The Blume-Emery-Griffiths Model with Biquadratic Repulsion."
- American Vacuum Society Meeting*, Chicago, Illinois, November 9-13, 1992.
- Pullman, D.P., Y.L. Li, J.J. Yang, and S.T. Ceyer. "Reaction Dynamics of F₂ on Si(100)."
- ALAA Space Programs and Technologies Conference*, Huntsville, Alabama, March 24-27, 1992.
- Canizares, C.R., D. Dewey, E.B. Galton, T.H. Markert, H.I. Smith, M.L. Schattenburg, B.E. Woodgate, and S. Jordan. "The MIT High Resolution X-ray Spectroscopy Instruments on AXAF."
- CLEO/QELS-Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science*, Anaheim, California, May 10-15, 1992.
- Jacobson, J.M., A.G. Jacobson, K. Naganuma, H.A. Haus, and J.G. Fujimoto. "Generation of 28-fs Pulses from a Ti:Al₂O₃ Laser Using Second- and Third-Order Intracavity Dispersion Compensation."
- Pritchard, D.E. "Atom Interferometry."
- Swanson, E., M. Hee, D. Huang, J.A. Izatt, J.G. Fujimoto, C.P. Lin, J.S. Schuman, and C.A. Puliafito. "Optical Coherence Tomography."

- Ulman, M., L.H. Acioli, C.J. Stanton, E.P. Ippen, and J.G. Fujimoto. "Studies of Intervalley Scattering Using Tunable Femtosecond Pulses."
- CLEO/QELS-Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science*, Anaheim, California, May 8-13, 1994.
- Cheng, T.K., M.S. Dresselhaus, and E.P. Ippen. "Direct Observation of Ultrafast Ionic Screening."
- CLEO/QELS-Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science*, Baltimore, Maryland, May 2-7, 1993.
- Ramaswamy, M., M. Ulman, J. Jacobson, and J.G. Fujimoto. "Femtosecond Cavity-dumped Kerr Lens Mode-locked Ti:Al₂O₃ Laser."
- Electronic Materials Conference*, Santa Barbara, California, June 21-23, 1993.
- Bahl, S.R., J.A. del Alamo, J. Dickmann, and S. Schildberg. "Physics of Breakdown in InAlAs/InGaAs MODFETs."
- European Workshop on Compound Semiconductor Devices and Integrated Circuits*, Parma, Italy, May 31-June 2, 1993.
- del Alamo, J.A., and S. Bahl. "InAlAs/InGaAs HFETs with High Breakdown Voltage."
- General Conference of the Condensed Matter Division of the European Physical Society*, 13th, Regensburg, Germany, March 29-April 2, 1993.
- Netz, R.R., and A.N. Berker. "Renormalization-Group Theory of the Blume-Emery-Griffiths Model with Repulsive Biquadratic Coupling."
- Gordon Research Conference on Aspects of Disorder in Condensed Matter Physics*, Wolfeboro, New Hampshire, June 28-July 2, 1993.
- Berker, A.N., and R.R. Netz. "Hard-Spin Mean-Field Theory and Frustrated Systems in d=2 and d=3."
- Gordon Research Conference on Gas-Surface Dynamics*, Andover, New Hampshire, August 2, 1993.
- Ceyer, S.T. "A New Mechanism for Dissociative Chemisorption on Si: Atom Abstraction."
- International Conference on the Physics of Semiconductors*, 21st, Beijing, China, August 10-14, 1992.
- Zhao, Y., D.C. Tsui, K. Hirakawa, M. Santos, M. Shayegan, R. Ghanbari, D.A. Antoniadis, and H.I. Smith. "Far Infrared Magneto-Absorption by the 2 DEG in GaAs/AlGaAs Heterostructures with Grid Gates."
- International Conference on InP and Related Materials*, Fourth, Newport, Rhode Island, May 21-24, 1992.
- Bahl, S.R., B.R. Bennett, and J.A. del Alamo. "A High-Voltage, Doubly-Strained In_{0.41}Al_{0.59}As/n⁺-In_{0.65}Ga_{0.35}As HFET."
- International Conference on Laser Spectroscopy*, Eleventh, Hot Springs, Virginia, June 13-18, 1993.
- Pritchard, D.E. "Atom Interferometry."
- International Conference on Solid State Devices and Materials*, Tsukuba, Japan, August 26-28, 1992.
- Smith, H.I., and D.A. Antoniadis. "Mesoscopic Devices: Will They Supersede Transistors in ULSI?"

International Conference on Thermodynamics and Statistical Mechanics, Berlin, Germany, August 2-8, 1992.

Berker, A.N. "Critical Behavior Induced by Quenched Disorder."

Netz, R.R., and A.N. Berker. "Smectic C/A₂ Order, Domains, Reentrance in a Microscopic Model of Liquid Crystals."

International Symposium on Electron, Ion and Photon Beams, 38th, New Orleans, Louisiana, May 31-June 3, 1994.

Burkhardt, M., H.I. Smith, D.A. Antoniadis, T.P. Orlando, M.R. Melloch, K.W. Rhee, and M.C. Peckerar. "Fabrication Using X-ray Nanolithography and Measurement of Coulomb Blockade in a Variable-sized Quantum Dot."

Hector, S.D., V.V. Wong, H.I. Smith, M.A. McCord, A. Wagner, and K.W. Rhee. "Printability of sub-150 nm Features in X-ray Lithography: Theory and Experiments."

Mondol, M., H. Li, G. Owen, and H.I. Smith. "Uniform-Stress Tungsten on X-ray Mask Membranes via He-Backside Temperature Homogenization."

Wong, V.V., J. Ferrera, J. Damask, J. Carter, E. Moon, H.A. Haus, H.I. Smith, and S. Rishton. "Spatial-Phase Locked E-Beam Lithography and X-ray Lithography for Fabricating First-Order Gratings on Rib Waveguides."

Yang, I.Y., H. Hu, L.T. Su, V.V. Wong, M. Burkhardt, E. Moon, J. Carter, D.A. Antoniadis, H.I. Smith, K.W. Rhee, and W. Chu. "High Performance Self-Aligned Sub-100 nm MOSFETs Using X-ray Lithography."

International Symposium on Integrated Optics Conference on Nanofabrication Technologies and Device Integration, Lindau, Germany, April 11-15, 1994.

Damask, J.N., J. Ferrera, V.V. Wong, H.I. Smith, L.A. Kolodziejski, and H.A. Haus. "Limitations and Solutions for the Use of Integrated QWS-DBR Resonators in WDM Applications."

Istanbul Technical University Statistical Physics Days, Istanbul, Turkey, July 14-15, 1994.

Falicov, A., and A.N. Berker. "Finite-Temperature Phase Diagram of the tJ Model: Renormalization-Group Theory."

IEEE Lasers and Electro-Optics Society Meeting, Annual, San Jose, California, November 15-18, 1993.

Tamura, K., L.E. Nelson, H.A. Haus, and E.P. Ippen. "Femtosecond Fiber Lasers (invited talk)."

Journées Microelectronique et Optoelectronique III-V, Fourth, Al Grande Motte, France, October 21-23, 1992.

Dumas, J.M., P. Audren, M.P. Favennec, S. Praquin, S.R. Bahl, and J.A. del Alamo. "Une Etude des Niveaux Profonds dans le Transistor a Effet de Champ de Puissance a Heterostructure InAlAs/n⁺-InGaAs."

New England Molecular Beam Epitaxy Workshop, Seventh, Cambridge, Massachusetts, May 13, 1992.

Bahl, S.R., B.R. Bennett, and J.A. del Alamo. "High Quality Heterostructures for Doubly-Strained InAlAs/InGaAs HFETs."

Optcon '92, Boston, Massachusetts, November 15-20, 1992.

Smith, H.I. "History of X-ray Lithography."

Optical Society of America Meeting, Annual, Albuquerque, New Mexico, September 20-25, 1992.

Fujimoto, J.G. "Femtosecond Lasers and Ultrafast Measurement Techniques."

Optical Society of America Meeting, Annual, Toronto, Canada, October 3-8, 1993.

Fujimoto, J.G., J.A. Izatt, M.R. Hee, D. Huang, E.A. Swanson, C.P. Lin, and C.A. Puliafito. "Biological Imaging Using Optical Coherence and Transillumination Tomography."

Physical Electronics Conference, Irvine, California, June 20-25, 1992.

Li, Y.L., J.J. Yang, D.P. Pullman, and S.T. Ceyer. "Reaction Dynamics of F_2 on $Si(100)$."

Statistical Mechanics Meeting, 70th, New Brunswick, New Jersey, December 15-17, 1993.

Berker, A.N. "Hard-Spin Mean-Field Theory."

Falicov, A., and A.N. Berker. "Finite-Temperature Phase Diagram of the tJ Model: Renormalization-Group Theory."

Statistical Mechanics Meeting, 71th, New Brunswick, New Jersey, May 11-13, 1994.

Aalberts, D.P., and A.N. Berker. "Spin-Wave Bound-State Energies from an Ising Model."

Falicov, A., and A.N. Berker. "A Correlated Random-Chemical-Potential Model for the Phase Transitions of Helium Mixtures in Porous Media."

Hui, K., and A.N. Berker. "Expression for the Superantiferromagnetic Boundary of the Ising Model with Nearest- and Next-Nearest-Neighbor Interactions on the Square Lattice."

Summer School on Recent Developments in Statistical Physics, Istanbul, Turkey, July 26-August 6, 1993.

Berker, A.N. "Phase Transitions in Disordered Systems."

SPIE International Society for Optical Engineering, Los Angeles, California, January 16-23, 1993.

Hee, M.R., J.A. Izatt, J.M. Jacobson, E.A. Swanson, and J.G. Fujimoto. "Time-Gated Imaging with Femtosecond Transillumination Optical Coherence Tomography."

SPIE International Symposium on Optical Engineering and Photonics, San Jose, California, March 7-9, 1992.

Smith, H.I., and M.L. Schattenburg. "Why Bother with X-ray Lithography?"

Topics in Statistical Physics Meeting, Antigonish, Nova Scotia, Canada, October 1-3, 1993.

Berker, A.N. "Hard-Spin Mean-Field Theory."

Towards Teraflop Computing Conference, Baton Rouge, Louisiana, February 9-12, 1994.

Cho, K., and J.J. Joannopoulos. "The Enchanting World of Surfaces."

Workshop on Compound Semiconductor Microwave Materials and Analog Devices, San Antonio, Texas, February 17-19, 1992.

Bahl, S.R., B.R. Bennett, and J.A. del Alamo. "Doubly-Strained $InAlAs/n^+-InGaAs$ HFETs."

1.1.7 Published Meeting Papers

- Arias, T., and J.D. Joannopoulos. "The View of Grain Boundaries and Segregation from the Computational Leading Edge." *Proceedings of the Electrochemical Society Meeting*
- Bahl, S.R., and J.A. del Alamo. "Physics of Breakdown in InAlAs/n⁺-InGaAs HFETs." *Proceedings of the Fifth International Conference on Indium Phosphide and Related Materials*, Paris, France, April 18-22, 1993.
- Coronado, C.A., E. Ho, L.A. Kolodziejski, and C.A. Huber. "Laser-Assisted Growth of ZnSe by Metalorganic Molecular Beam Epitaxy." *Proceedings of the Material Research Society Symposium*, 263: 181-186, San Francisco, California, April 27-May 1, 1992.
- Dickmann, J., S. Schildberg, H. Dambkes, S.R. Bahl, and J.A. del Alamo. "Characterization of the Breakdown Behavior of Pseudomorphic InAlAs/In_xGa_{1-x}As/InP HEMTs with High Breakdown Voltages." *Proceedings of the 20th International Symposium on Gallium Arsenide and Related Compounds*, Freiburg, Germany, August 29-September 2, 1993.
- Dumas, J.M., P. Audren, M.P. Favennec, D. Lecrosnier, S.R. Bahl, and J.A. del Alamo. "An Investigation of Deep Levels in InAlAs/n⁺-InGaAs Heterostructure FETs." *Proceedings of the Fifth International Conference on Indium Phosphide and Related Materials*, Paris, France, April 18-22, 1993.
- Fisher, P.A., E. Ho, G.S. Petrich, L.A. Kolodziejski, M.S. Brandt, and N.M. Johnson. "N- and P-Type Doping of ZnSe Using Gas Source Molecular Beam Epitaxy." *Proceedings of the Material Research Society Symposium*, San Francisco, California, March 1994.
- Haus, H.A., and F.X. Kartner. "On the Theory of Quantum Measurement." *Proceedings of the Third International Workshop on Squeezed States and Uncertainty Relations*, Baltimore, Maryland, August 10-13, 1993.
- Hultgren, C.T., K.L. Hall, D.J. Dougherty, G. Lenz, and E.P. Ippen. "Spectral-Hole Burning and Carrier Heating Nonlinearities in Active Waveguides." *Proceedings of the Optical Society of America Topical Meeting on Ultrafast Electronics and Opto-electronics*, San Francisco, California, January 25-27, 1993.
- Natarajan, V., K.R. Boyce, F. DiFilippo, and D.E. Pritchard. "Improved Precision Mass Comparison in a Penning Trap - Techniques and Results." *Proceedings of the Ninth International Conference on Atomic Masses and Fundamental Constants*, Bernkastel-Kues, Germany, July 19-24, 1992. Institute of Physics Conference Series.
- Pritchard, D.E. "Atom Interferometers." *Proceedings of the International Conference on Atomic Physics, 13th*, Munich, Germany, August 3-7, 1992.
- Pritchard, D.E., and W. Ketterle. "Atom Traps and Atom Optics." *Proceedings of the Enrico Fermi International School of Physics*, Varenna, Italy, June 1993.
- Schattenburg, M.L., K. Li, R.T. Shin, J.A. Kong, D.B. Olster, and H.I. Smith. "Electromagnetic Calculation of Soft X-ray Diffraction from 0.1 μm -scale Gold Structures." *Proceedings of the 35th International Symposium on Electron, Ion, and Photon Beams*, Seattle, Washington, May 28-31, 1991, Paper E84.
- Schattenburg, M.L., J. Carter, W. Chu, R.C. Fleming, R.A. Ghanbari, M. Mondol, N. Polce, and H.I. Smith. "Mask Technology for X-ray Nanolithography." *Proceedings of the Materials Research Society Spring Meeting Symposium*, San Francisco, California, April 12-16, 1993.